INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: METHOD, DEVICE AND DATA COMMUNICATION SYSTEM FOR MULTILINK POLLING
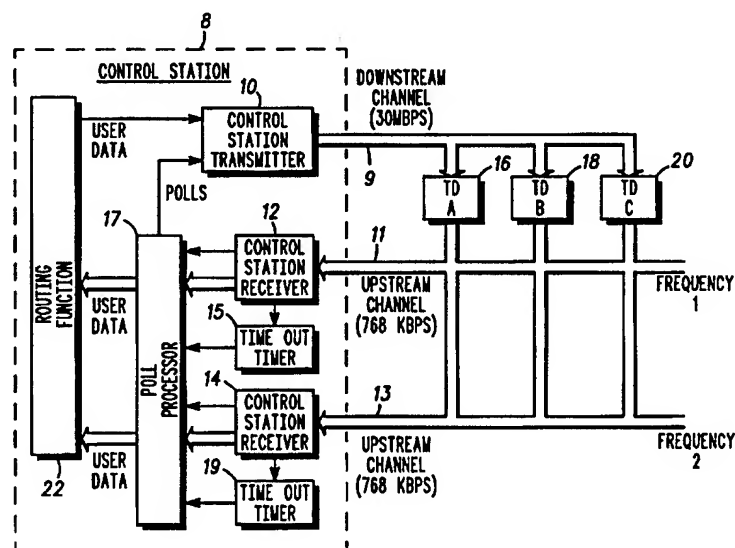
(57) Abstract

A control station (8) is coupled to a plurality of tributary devices (16, 18, 20) by way of at least one high speed broadcast downstream data channel (9) and more than one shared lower speed upstream data channels (11, 13). The control station (8) broadcasts data to all the tributary devices (10, 16, 18) and selects a channel for a specific tributary device (16, 18, 20) to respond to a poll. After polling, the tributary device (10, 16, 18) changes the tributary device transmitter (42) to the frequency of the selected channel. The tributary device (16, 18, 20) either sends data to send to the control station (8) or sends a negative acknowledge to the control station (8). If a negative acknowledgment was transmitted, the control station (8) notifies the control station transmitter (10) that the channel is idle.

METHOD, DEVICE AND DATA COMMUNICATION SYSTEM FOR MULTILINK POLLING

Field of the Invention

5

This invention relates generally to data communication systems, and more particularly to a multilink polling device and method in data communication systems.

10   ## Cross reference to Related Applications

This application is related to the following United States Patent Applications, all assigned to the assignee of this application, incorporated by reference herein, as follows:

15

CXO95004   METHOD AND APPARATUS FOR A HYBRID CONTENTION AND POLLING PROTOCOL

20   CXO95005   METHOD AND SYSTEM FOR PROVIDING ACCESS BY SECONDARY STATIONS TO A SHARED TRANSMISSION MEDIUM

25   CXO95008   METHOD AND SYSTEM FOR MANAGEMENT OF FREQUENCY SPECTRUM AMONG MULTIPLE APPLICATIONS ON A SHARED MEDIUM

30

CXO95009   METHOD AND APPARATUS FOR A HYBRID LIMITED CONTENTION AND POLLING PROTOCOL

35   CXO95011   SYSTEM AND METHOD FOR HYBRID CONTENTION/POLLING PROTOCOL COLLISION RESOLUTION USING A COLLISION RESOLUTION USING A DEPTH FIRST SEARCH TECHNIQUE

2

CXO95012   METHOD AND SYSTEM FOR
                MANAGEMENT OF FREQUENCY
                SPECTRUM AMONG MULTIPLE
5   APPLICATIONS ON A SHARED
                MEDIUM

10   **Background of the Invention**

In some high speed data applications, a number of low speed
links are combined to achieve high speed data transfer. In
simple point to point applications, inverse multiplexing
15   techniques allow a plurality of slow speed channels to be
used as a single high speed channel. Inverse multiplexing
can be done at physical, link, or network layers with various
advantages, disadvantages, and complexities at each layer.

20   In point to multipoint applications, another layer of
complexity is added. Point to multipoint applications are
those where a control station has a broadcast, or
downstream, channel that reaches a plurality of tributary
stations. The plurality of tributary stations share access to
25   an upstream channel or channels which reach the control
station. As an added complexity, access to the upstream
channel(s) must be controlled.

In such an application, the problems associated with
30   controlling access to the upstream and downstream channels
is typically dealt with separately from the problem of
accomplishing high speed data transfer through the system
over multiple lower speed channels.

35   The channel access problem may be dealt with through
polling, contention access, or hybrid combinations of the two.
The multilink problem is typically dealt with through inverse
multiplexing, or through static

assignment of subsets of tributary devices to specific upstream channels.

Inverse multiplexing is typically accomplished with complicated and expensive hardware or software solutions. Inverse multiplexing typically requires a start-up synchronization time each time a device begins transmitting. And inverse multiplexing requires the transmitting device to pass data at a speed equal to the sum of all of the low speed channels.

Static assignment of tributary devices to upstream channels does not allow the bandwidth to be utilized efficiently. If a number of users assigned to a channel all have their bandwidth requirements peak concurrently, then their data becomes congested, even if their are other channels in the system which are idle.

A more efficient method of controlling access to the upstream channel while providing efficient utilization of the upstream channel is therefore needed.

Brief Description of the Drawings

FIG. 1 is a block diagram of a data communication system.
FIG. 2 is a block diagram of the tributary station.
FIG. 3 is a flow chart of a tributary station.
FIG. 4 is a flow chart of a control station.

Detailed Description of the Drawings

A method of combining polling type channel access with dynamic assignment of upstream channels provides efficient utilization of the plurality of upstream channels across a population of tributary stations.

4

When the control station generates polls for a tributary, the control station includes a channel identifier (CID) in the poll message indicating which upstream channel the tributary can respond on. The tributary must use the specified
5   upstream channel

This method allows an individual tributary to fully utilize one link. It also allows multiple tributaries to be balanced across the multiple links, maximizing bandwidth efficiency
10   and minimizing congestion. As long as the bandwidth provided by one link is sufficient for one tributary, this approach allows the use of simpler, less expensive tributaries.

15   This protocol also avoids the problems associated with allowing multiple links to be used by a tributary simultaneously, such as the need to re-sequence out-of-sequence frames and delay problems that arise due to different links having different characteristics (e.g., link
20   speed, propagation delay, error rate, etc.) and allows the tributaries to require no intelligence related to choosing a link to transmit on. Since the quality of links may vary from tributary to tributary in some environments, the control station can direct a specific tributary to use links that are
25   considered high quality for the specific tributary.

FIG. 1 shows a data communication system 6. Control station (which could be a cable router) 8 broadcasts on downstream channel 9 to a plurality of tributary stations 10,
30   16, 18. Tributary stations 10, 16, 18 send data to control station 8 by way of a plurality of upstream channels 11, 13.

Control station 8 has two primary components for communication with tributary stations 10, 16, 18.
35   Transmitter 10 sends data and control information from the control station 8 to the tributary stations
10, 16, 18.   Receiver 12 is connected to upstream
channel 11,   and receiver 14 is connected to upstream
channel 13.   One receiver is needed for each

independent   channel carrying data and control information from the tributary stations 10, 16, 18 to the control station 8.

5   In the downstream direction, control station 8 transmits data packets and control packets which are received by tributary stations 10, 16, 18. Each packet is given a packet identifier which specifies which of the tributary stations 10, 16, 18 should accept the data. For purposes of this invention,
10   downstream packets can be classified as 'data packets' or 'polls'. Polls are used to grant a particular tributary station access to a specified upstream channel.

Upon receipt of a downstream packet, each tributary station
15   10,1 6, 18 checks the packet identifier to determine if the downstream packet is for the particular tributary station. If the packet is for the tributary station, then it is checked to see if the downstream packet is a 'data packet' or a 'poll'. Data packets are forwarded to an end user interface.
20
Upon receipt of a poll, a tributary station will tune its transmitter 42 (see Fig. 2) to the specified channel. Then, the tributary station transmits user data in the upstream direction. If there is no data for the tributary to send, then it
25   sends a negative acknowledgment (NAK) to indicate this to the control station.

Receivers 12, 14 wait for upstream packets. When received, the receivers 12, 14 sends a message to the poll processor 17
30   that the upstream channel 11, 13 can now be used for polling another tributary station 10, 16, 18. The receiver also sends a ·message to restart the time out timer 15, 19. The poll processor 17 chooses the next tributary station 10, 16, 18 to be polled and sends the poll to the control station transmitter 1
35   0. The control station transmitter 10 sends the next poll out on the downstream channel 9.

If a downstream poll has a transmission error, or if a tributary station 10, 16, 18 is powered off then some polls will

not generate a response. If a response to a poll is not
received then the time out timer 15,19 will expire. At this
point the time out timer 15, 19 will generate a message to the
poll processor 17 that the upstream channel 11, 13 is idle and

5   can be polled again. The poll processor 17 can correlate
messages from time out timers 15, 19 with particular
tributary stations 10, 16, 18 and stop polling them (or poll
them less frequently) if they are not responding.

10   FIG. 2 is a block diagram of a tributary station. A tributary
station receiver 30 is tuned to the downstream channel 9.
Receive data filter 32 differentiates between packets for this
tributary station and other tributary stations . Packets
destined for other stations are discarded. Receive data filter

15   32 also differentiates between data packets and polls. Data
packets are forwarded to user data interface 36, while polls
are forwarded to poll processor 34. User data interface 36
could be coupled to a data terminal equipment.

20   Poll processor 34 decodes the poll, and tunes the transmitter
to the appropriate frequency through frequency selector 40.
Upstream user data is stored in transmit data buffer 41 until
a poll is received. Poll processor 34 signals the transmit data
buffer to send the upstream data to the tributary station

25   transmitter 42. If there is no data in the data buffer, then a
NAK is sent instead.

FIG. 3 shows the normal processing flow through a tributary
station. Each packet that is broadcast from the control

30   station is received and checked (100). If it is for some other
tributary device, then it is discarded. If it is for this device, it
is checked to determine if it is a data packet or a poll (1 02). If
it is a data packet, then the data is forwarded to the end user.
If it is a poll, then the tributary's transmitter is tuned to the

35   channel specified in the poll (104). The transmit data buffer
41 is checked to see if there is any data (106). If so, the data is
transmitted (108). Otherwise, a NAK is transmitted (110).

FIG. 4 shows the normal poll processing flow through control station 8. The process begins with an indication from a control station receiver 12, 14 to the control station transmitter 1 0 that an upstream channel 12, 14 is idle (200).

5 The control station receiver 12 also starts time out timer 15 when the idle notification is sent to the control station transmitter 1 0 (200). The control station transmitter 1 0 selects the next tributary device from its list of devices to be polled (202). The transmitter must make sure that the device

10 to be polled is not already being polled on another upstream channel. A poll packet is created which contains the tributary identification (ID) and the idle channel (204). This packet is transmitted on the broadcast channel to all of the tributary devices (206).

15
At the tributary station, the packet is received and interrogated to determine if the packet is a data packet or an NAK (208). Additionally, the time out timer 15 may expire due to no response to the poll.

20
If a data packet is received, the data is forwarded to the end user (21 0).

If a NAK is received, a notification is sent to a poll processor

25 34. (212) The poll processor could cause more or less frequent polling of specific tributary devices based upon how often the tributary device has real data in response to polls.

If a time out occurs, a notification is sent to the poll processor

30 34. A time out might occur for several reasons. A broadcast poll may have had a transmission error, resulting in no tributary station responding. Or the addressed tributary station for a poll may have been shut down or failed. Algorithms in the poll processor 34 could correlate time out

35 events and take appropriate action regarding continued polling of any specific devices.

After any of the three potential response types, the receive channel is considered idle, and the transmitter is notified so

8

that the next tributary device can be polled (200) The time out timer 15 is reset.

The method described herein allows a system to attain the performance characteristics of a high speed shared channel upstream by using multiple lower speed channels. By using lower speed channels, a more cost effective tributary device can be used. Further, dynamic allocation of upstream channels through polling automatically accomplishes load balancing across the channels. Static assignment models need a higher level algorithm to re-assign statistically mapped channels in response to congestion.

9

CLAIMS

We claim:

5   1.   In a data communication system where a control
station is coupled to a plurality of tributary devices by way of
at least one high speed broadcast downstream data channel
and more than one shared lower speed upstream data
channels, each of the shared lower speed upstream channel
10   having a channel frequency, a method for controlling access
to the shared lower speed upstream transmission data
channels by the plurality of tributary devices comprising:

Broadcasting control station data from the control
15   station to the plurality of tributary devices on the at least one
high speed broadcast downstream data channel;
selecting a select shared lower speed upstream data
channel
sending a poll to a select tributary device; and sending
20   from the select tributary device to the control station on the
select shared lower speed upstream data channel a response
to the poll.

2.   The method of claim 1 further including:
25
receiving, by the select tributary device, the control
station data from the control station;
determining, by the select tributary device, if the
control station data contains a poll; and
30   changing, by the select tributary device, a tributary
device transmitter to the channel frequency of the select
shared lower speed upstream channel.

3.   The method of claim w further including the step of:
35
if the select tributary device has tributary device data
to send to the control station, sending the tributary device
data to the control station on the select shared lower speed
upstream channel.

10

4.   The method of claim 3 further including the step of:

5   if the select tributary device does not have tributary
device data to send, sending a negative acknowledge to the
control station.

5.   The method of claim 4 further including the step of:

10   if the select tributary device sent tributary device data,
forwarding the tributary device data for further processing.

6.   The method of claim 5 further including the step of:

15   if the select tributary device sent a negative
acknowledgment, notifying a control station transmitter that
the select shared lower speed upstream channel is idle.

7.   In a data communication system where a control
20   station is coupled to a plurality of tributary device by way of
at least one high speed broadcast downstream data channel
and more than one shared lower speed upstream data
channels, a method for controlling access to the shared lower
upstream transmission data channels by the plurality of
25   tributary devices comprising:

AT THE CONTROL STATION:

      (a)   broadcasting data to the plurality of tributary
30   devices
      (b)   Selecting a shared lower speed upstream data
      channel for a select tributary device to respond to a
      poll;
      (c)   sending a poll to the select tributary device;
35   (d)   waiting to receive a response to the poll;

AT THE SELECT TRIBUTARY DEVICE:

      (e)   receiving the data from the control station;

(f)   determining if the data contains a poll;
(g)   changing a tributary device transmitter of the select tributary device to the select channel;
(h)   if the select tributary device has tributary device data to send to the control station, sending the tributary device data to the control station on the selected channel; and
(i)   if the select tributary device does not have tributary device data to send, sending a negative acknowledge to the control station.

8.   The method of claim 7 further comprising, at the control station, the step of:

(j)   if the select tributary device sent tributary device data, forwarding the tributary device data for further processing.

9.   The method of claim 8 further comprising, at the control station, the step of:

(k)   if the select tributary device sent a negative acknowledgment, notifying the transmitter that a shared lower speed upstream data channel is idle.

10.   A tributary device coupled to a control station by way of at least one high speed broadcast downstream data channel for sending control station data from the control station to the tributary device and more that one shared lower speed upstream data channel for sending tributary device data to the control station comprising: a tributary device receiver for receiving the control station data from a control station on the at least one high speed broadcast downstream data channel;

a tributary device transmitter for transmitting the tributary device data to the control station on a select shared lower sped upstream data channel, (the tributary device transmitter coupled to a plurality of upstream channels);

FIG.1

FIG.2

RECEIVE
PACKET
FROM CONTROL
STATION

IS
PACKET FOR TRIBUTARY
DEVICE
?   —100

NO, DISCARD

YES

DATA OR POLL
?   —102

DATA
FORWARD
TO USER

POLL

TUNE TRANSMITTER   —104

IS THERE
DATA IN BUFFER
?   —106

NO   YES

SEND NAK   SEND DATA

—110   108—

FIG.3

3/3

```
                        ┌─────────────────────┐
                        │ SELECT NEXT TRIBUTARY│──202
                        │ DEVICE FROM POLL LIST│
                        └─────────────────────┘
                                  │
                        ┌─────────────────────┐
                        │  CREATE POLL PACKET  │
                        │ WITH TRIBUTARY DEVICE ID│──204
                        │ AND UPSTREAM CHANNEL ID │
                        └─────────────────────┘
                                  │
                        ┌─────────────────────┐
                        │  TRANSMIT PACKET TO  │──206
                        │  TRIBUTARY DEVICES   │
                        └─────────────────────┘
                                                    AT THE CONTROL STATION
  - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                    AT THE TRIBUTARY DEVICE
```

SELECT NEXT TRIBUTARY DEVICE FROM POLL LIST — 202

CREATE POLL PACKET WITH TRIBUTARY DEVICE ID AND UPSTREAM CHANNEL ID — 204

TRANSMIT PACKET TO TRIBUTARY DEVICES — 206

AT THE CONTROL STATION

AT THE TRIBUTARY DEVICE

208

NAK, DATA, OR TIMEOUT ?

NAK   DATA

TIME OUT

210

NOTIFY POLL PROCESSOR   NOTIFY POLL PROCESSOR   FORWARD DATA TO END USER

NOTIFY TRANSMITTER OF IDLE UPSTREAM CHANNEL START TIME OUT TIMER — 200
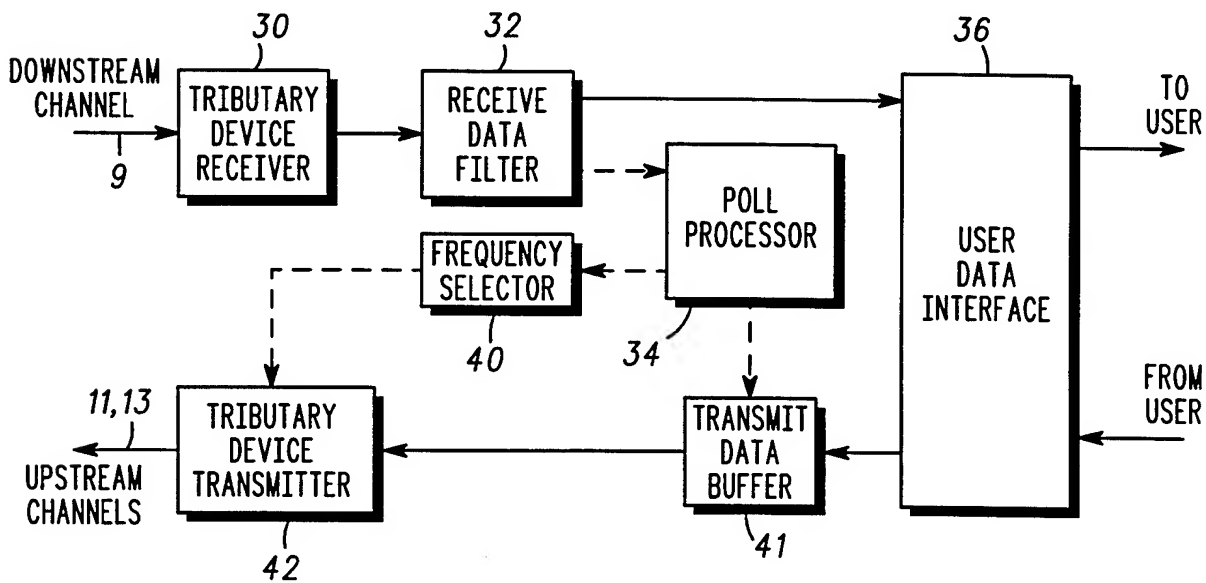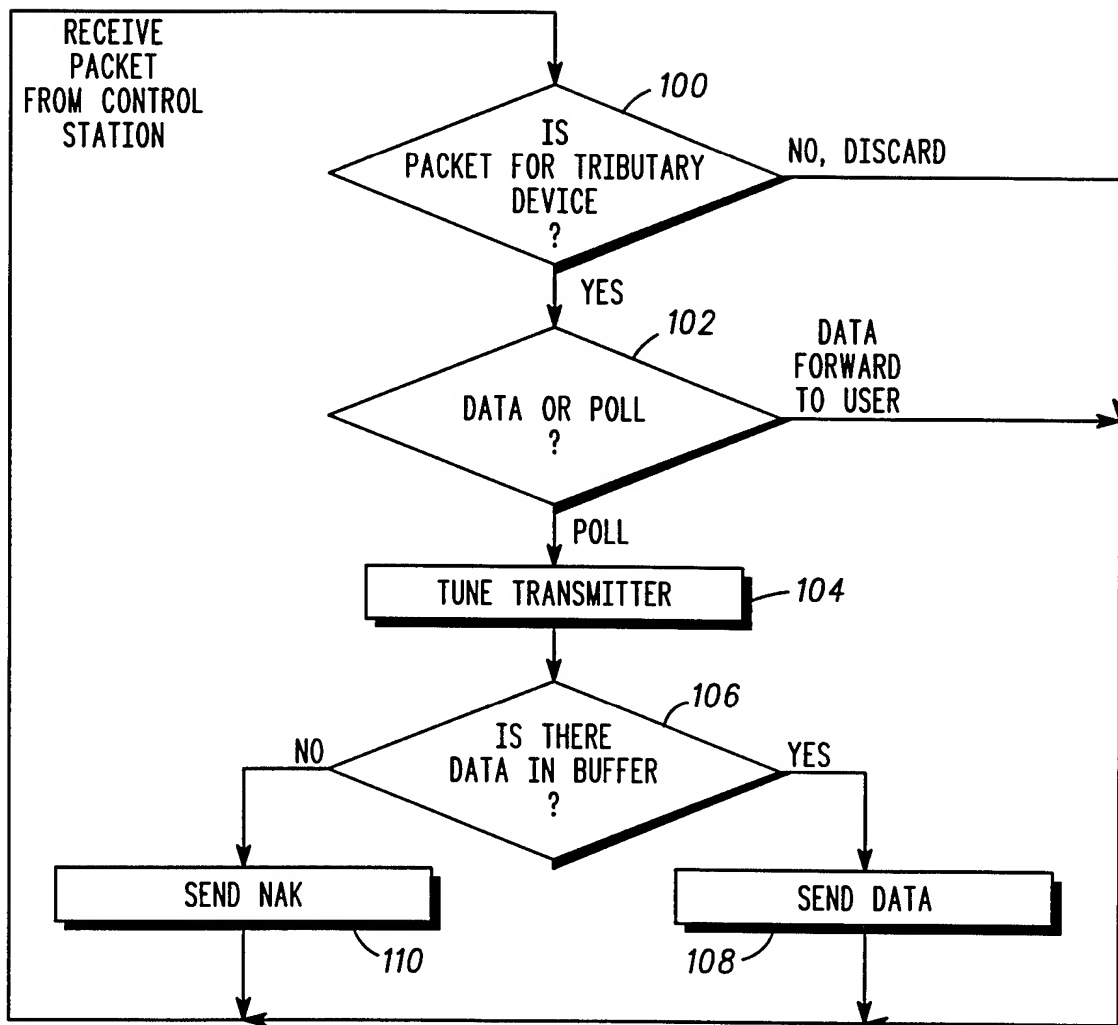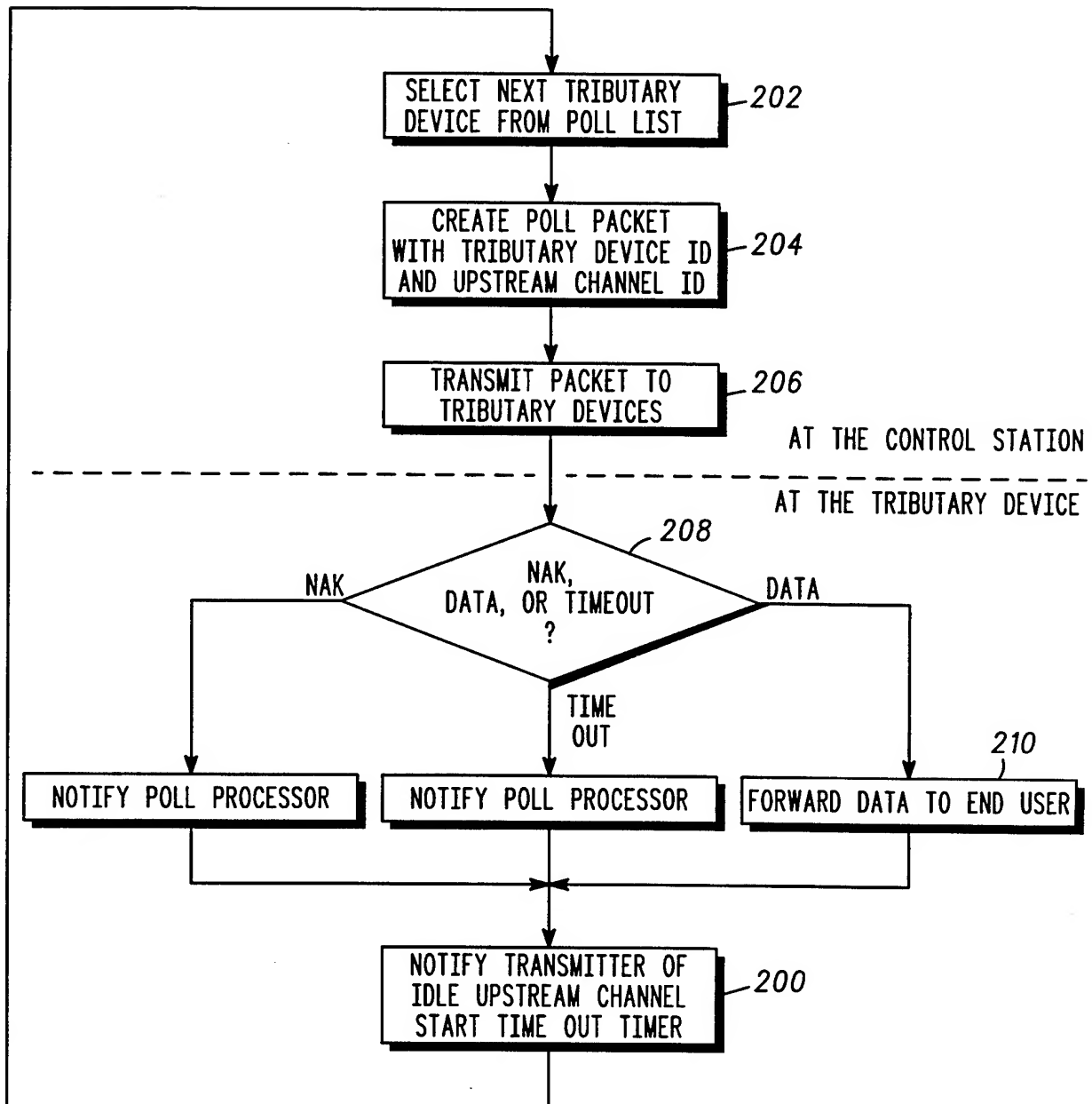
FIG.4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/05999

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6)   :HO4Q 11/00
US CL   :370/85.8, 95.2; 340/825.08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. :   370/29, 30, 85.7, 85.8, 95.1, 95.2, 85.1, 94.1, 94.3, 93, 95.3, 104.1; 340/825.07, 825.08, 825.54; 455/53.1, 54.1, 54.2

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

search items: transmitter, receivers, control?, poll?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,872,003 (YOSHIDA) 03 October 1989, see entire document.	1-10
A	US, A, 4,742,335 (VOGT) 03 May 1988, see entire document.	1-10
A	US, A, 5,347,515 (MARINO) 13 September 1994, Figure 2.	1-10
A	US, A, 5,132,680 (TEZUKA ET AL.) 21 July 1992, Fig. 3, Fig. 5, and Fig. 6.	1-10

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 JUNE 1996	T 2 JUL 1996

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	SEEMA S. RAO
Facsimile No. (703) 305-3230	Telephone No. (703) 308-5463

Form PCT/ISA/210 (second sheet)(July 1992)*